



# *Distributed Sensor Network for Retargeting*

**one of two Army Research Laboratory parcels  
of Multi-Role Armament and Ammunition Suite ATD**

*Armaments for Army Transformation Symposium*  
20 June 2001

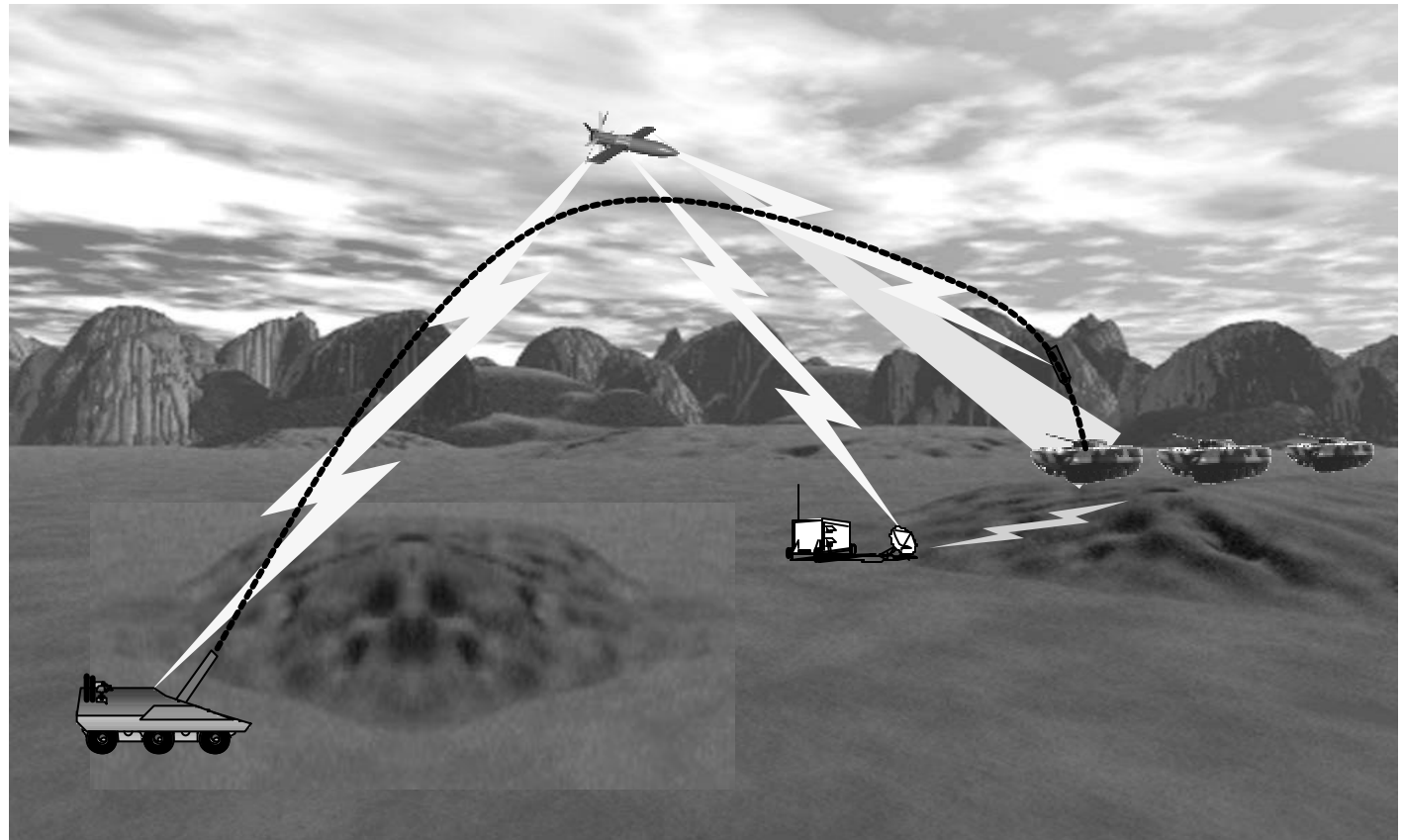
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# Distributed Sensor Network for Retargeting for Multi-Role Armament and Ammunition Suite ATD

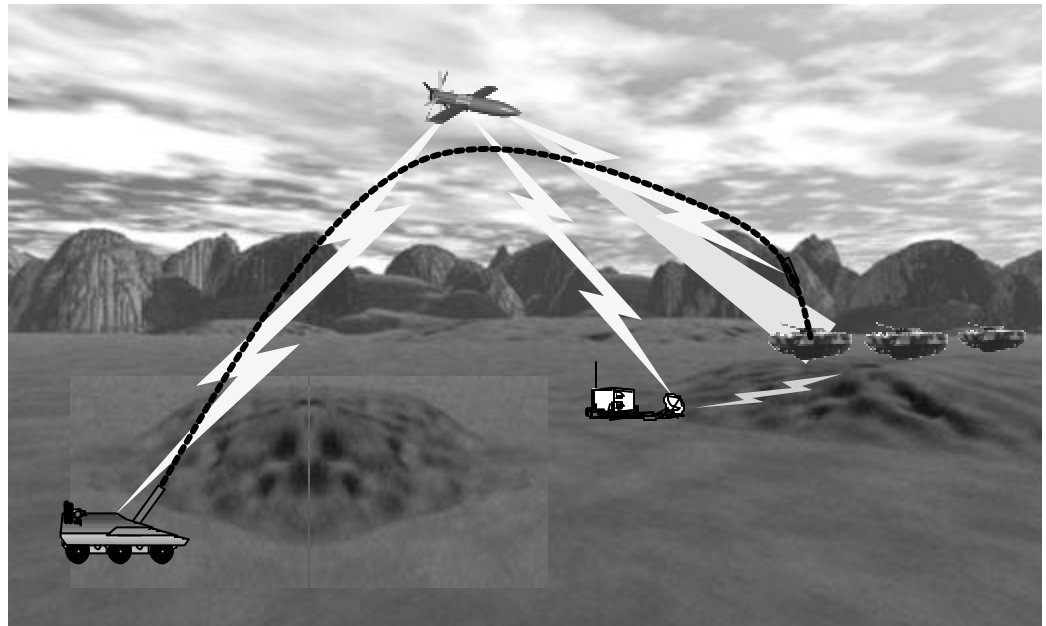


**Objective:** Conceive, model, and assess approaches to dynamic re-targeting within a simulation framework that permits virtual experimentation.

## Technical Approach:

- Develop simulation framework that integrates digital map data, sensor models, target models, networking, communication, and battlefield dynamics.
- Model FCS-compatible targeting sensors.
- Evaluate potential for new sensor capabilities to provide relevant and timely location information for indirect-fire extended range munitions.

**Benefit:** Permit trialing of notional networks of sensors and assessment of enabling capability of “one shot...at least one kill...”



## Status:

- Developed initial simulation framework that integrates digital map data, RF sensor models, simple target models, and battlefield dynamics.
- Developed Graphical User Interfaces to define sensor and target configurations.
- Integrated two RF sensor models.

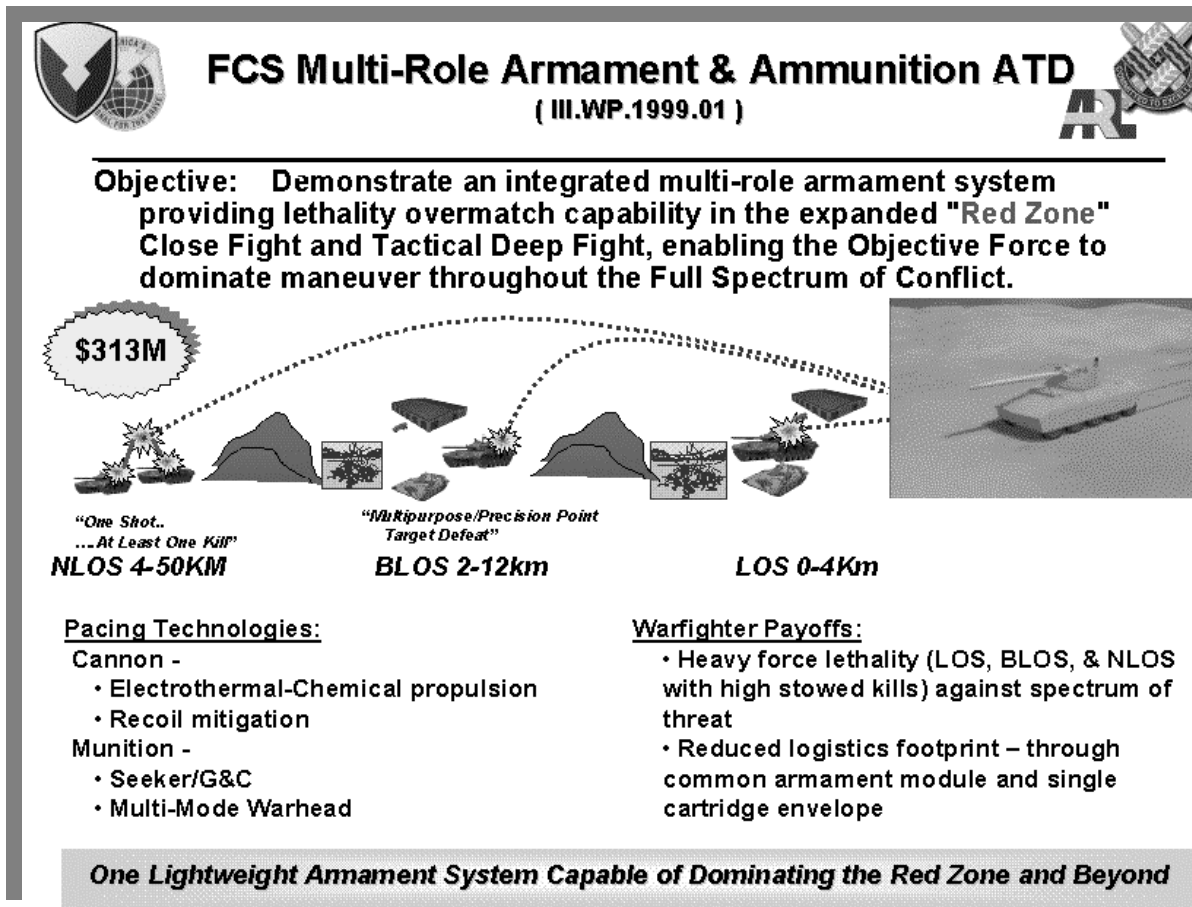


# “One Shot, ...at Least One Kill”

## - Extraordinary Demands on Sensors



- The Targets Must be Detected and Located,
- Ideally, Signature Data will be Uplinked Dynamically (or, In Flight).
- Distributed Micro-Sensors Helps Provide the Eyes and Ears for this Emerging System





# FO/Scout Options

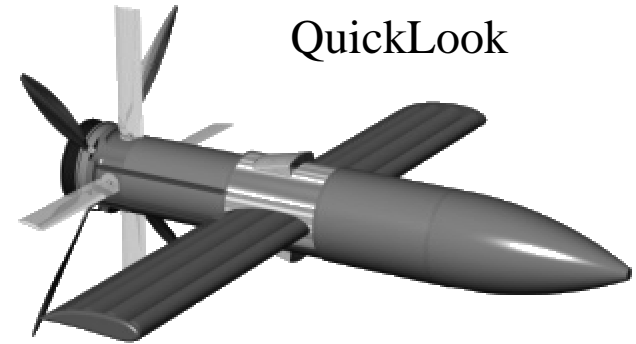
Thermal Weapon Sight



MULES



QuickLook



TUAV



UGS



Future Scout Vehicle



## Key Attributes of Planned Effort



- Construct a dynamic environment capable of monitoring crucial issues such as battery life, tracking accuracy, and effectiveness of cross-cueing strategies.
- Determine the amount of militarily significant information available (i.e., Probability of detect, location accuracy, timeliness, etc.) from notional sensor networks.
- Use as a yardstick to judge the value of individual sensor technologies and their complexity.

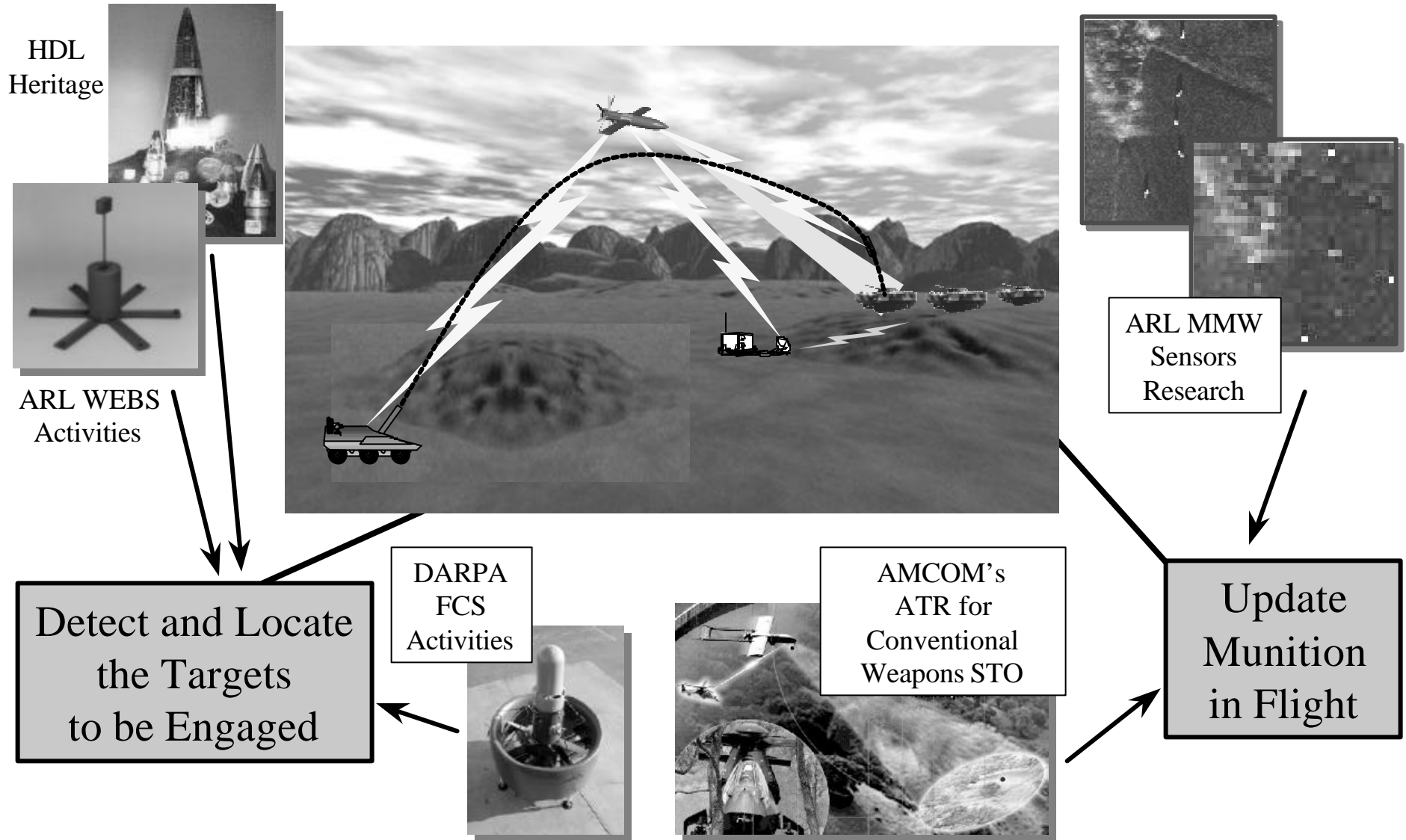


## (Just Some) Crucial Issues

- Sensor Deployment Concept
  - Loitering Micro-UAV
  - Unmanned Ground Sensors Deployed from Artillery, UAV, UGV, etc.
- Sensor Mobility/Relocatability
- Sensor Recoverability
- Individual Sensor Location Accuracy
- Individual Sensor Performance
  - Sensor Coverage Map and Near-Ground Propagation Effects
  - Resolution
- Autonomous Network Command, Control and Cueing
  - Self-organizing ad hoc networks
- Sensor Fusion
  - Within Class - Tracking and Beamforming
  - Between Class - Refined Detection, Tracking and Classification



# Two Significant Capabilities Needed

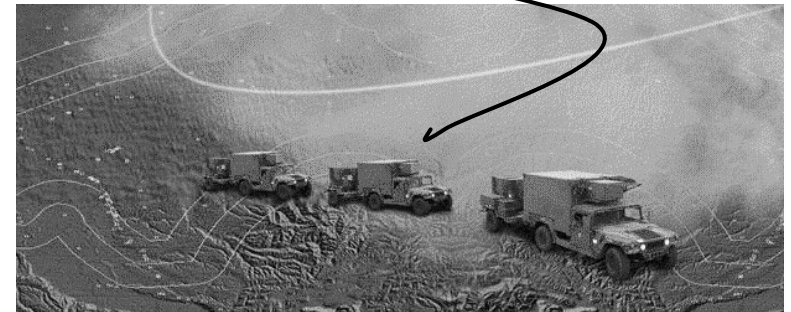
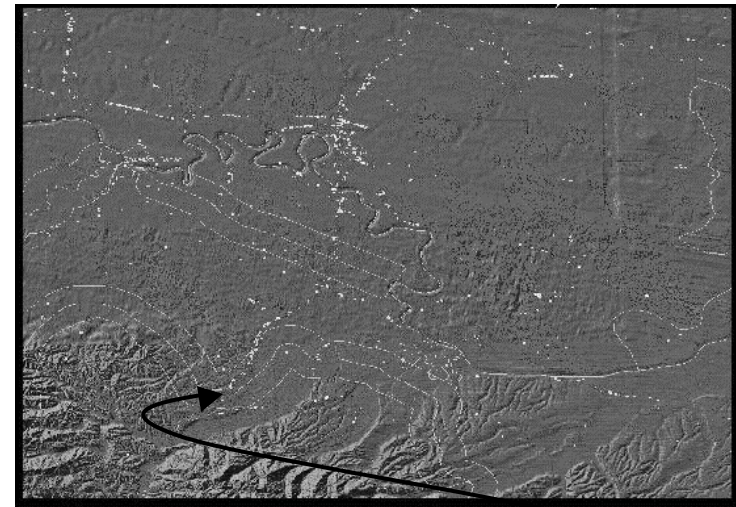




# Initial Strategy



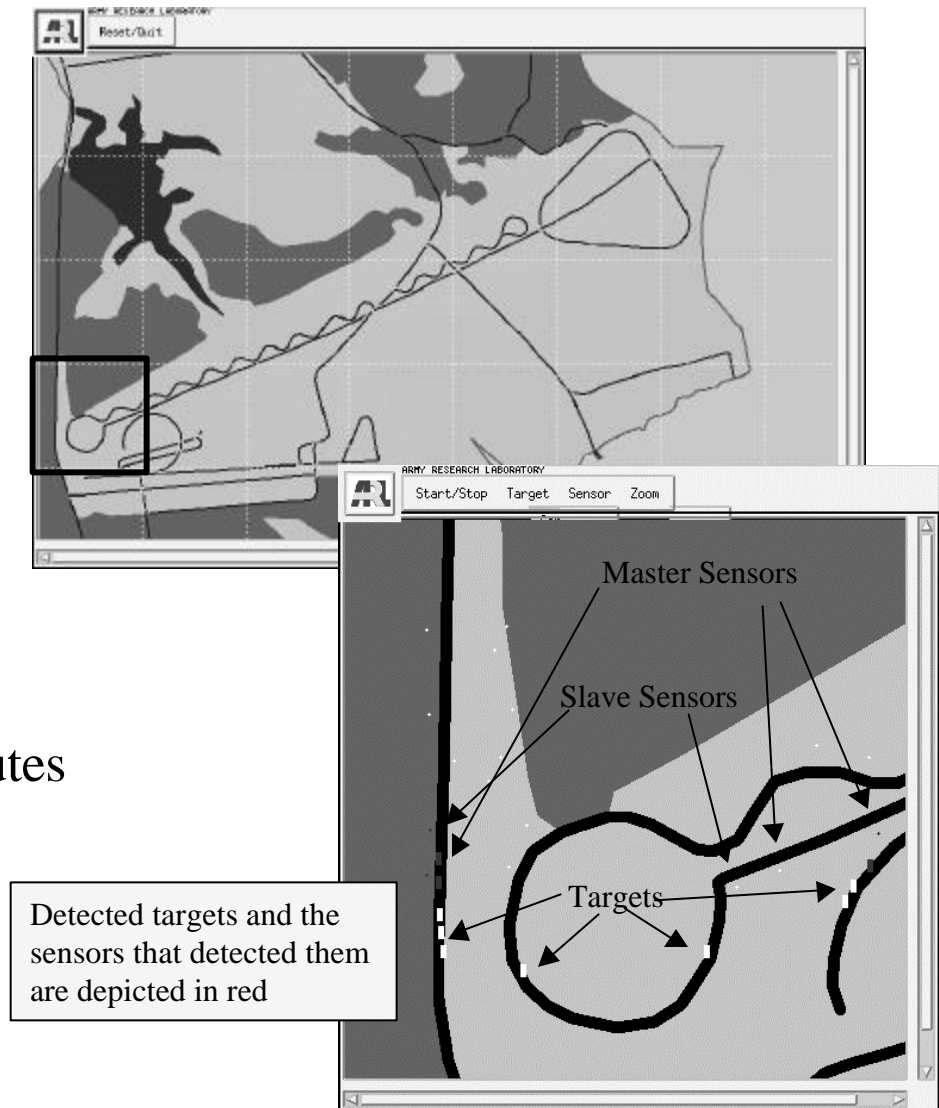
- Develop an Overarching Framework for Experimentation
  - Brigade-Sized Playing Field
  - Identify Variables to be Modeled and Monitored
- Concentrate on a Lucrative Sensor Concept and Construct Appropriate Sensor Performance Model
  - L-Band Multi-Function Sensor
- Place Sensors in a Faithful Battlespace Representation
  - Include Elevation and Feature Data Bases
- Exercise Dynamics of the Battlespace
- Assess Sensor Complexity Versus Military Utility of the Sensor Outputs
  - Monitored Outputs Compatible with WMRD Needs





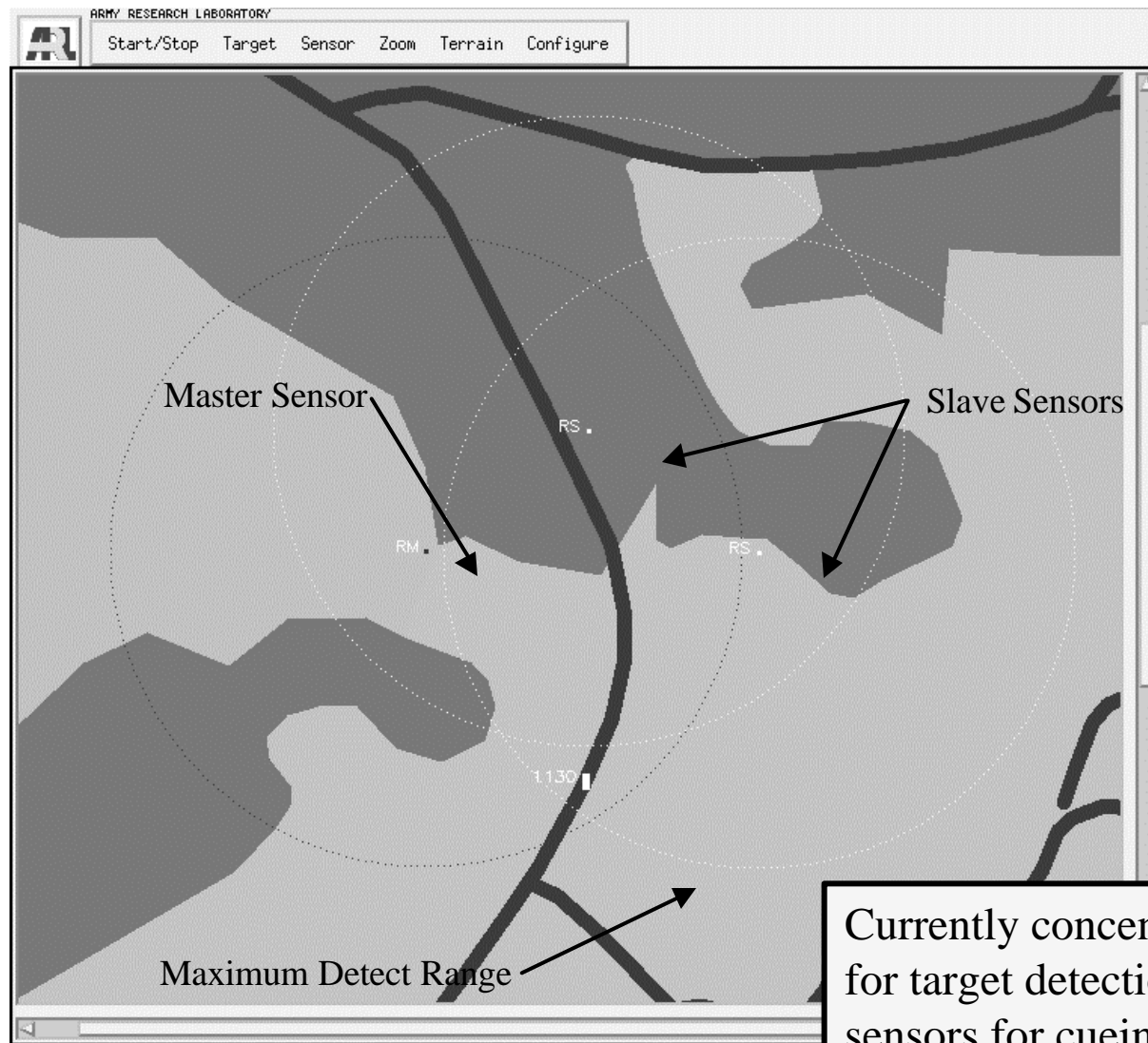
# Simulation Procedure

- Enter Digital Map Data
  - Terrain characteristics
- Deploy Individual Sensors
  - Performance characteristics/  
coverage map
- Define Cueing Strategy
  - Passive sensors “wake up”  
active sensors
- Develop Target Scenarios
  - Type, initial position,  
speed and path
- Monitor Sensor Performance Attributes
  - Target detected
  - Information dissemination
  - Battery life
- Playback and Assess





# GUI for Custom Sensor Configuration



Sensor 1 Type

Master/Slave

Position  
232

Heading (deg)  
11

Pitch (deg)  
5

Roll (deg)

Currently concentrating on L-band RF sensors for target detection with acoustic and magnetic sensors for cueing.



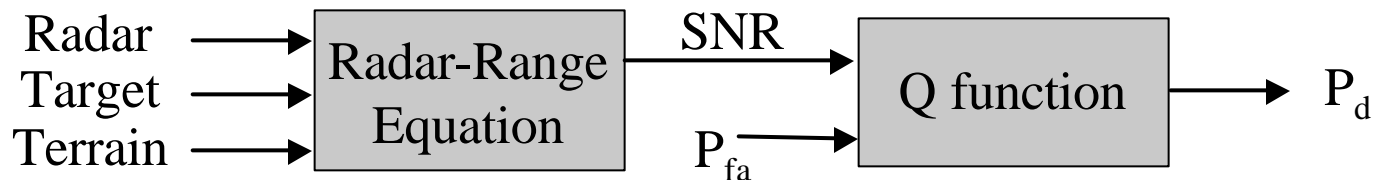
# Simulation of RF Sensors

Modular software package capable of performance predictions for variety of radar systems.

- step-frequency to chirped waveforms.
- stationary to airborne systems.

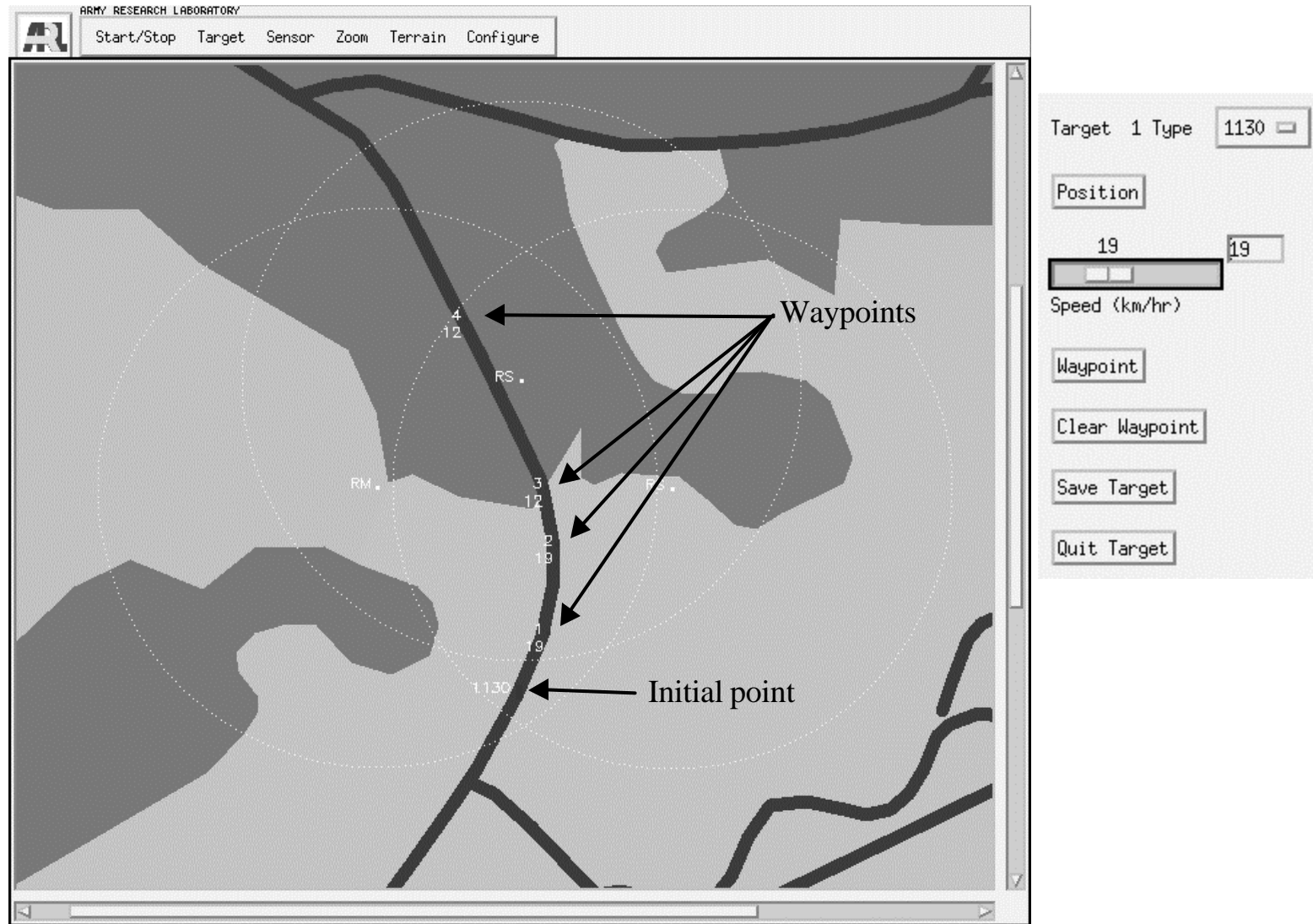
Calculate detection probability for each velocity, range-gate cell

Input  
Parameters





# GUI for Custom Target Configuration



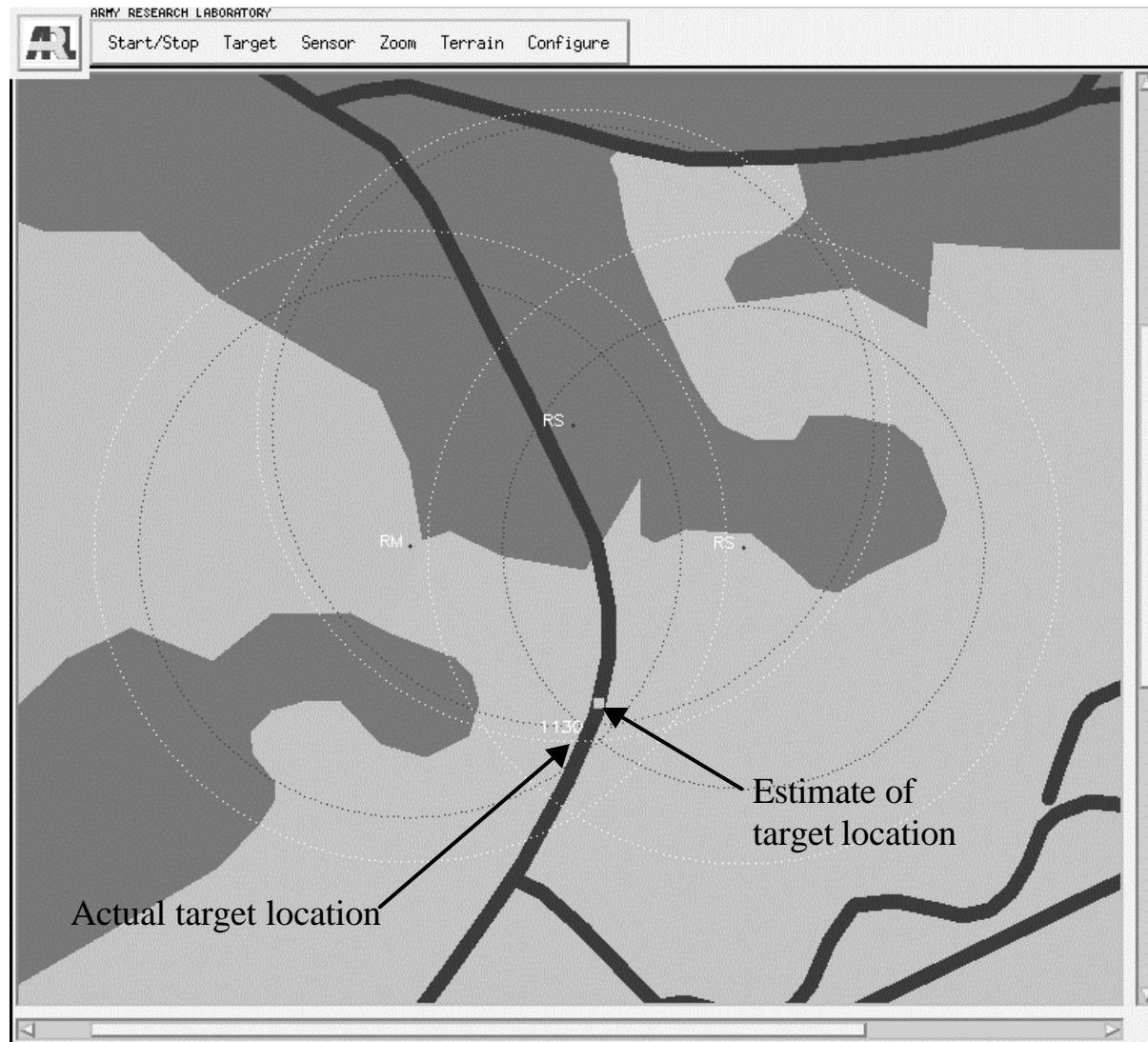


# Target Detects





# Fusion of Detects of Low Resolution Sensors



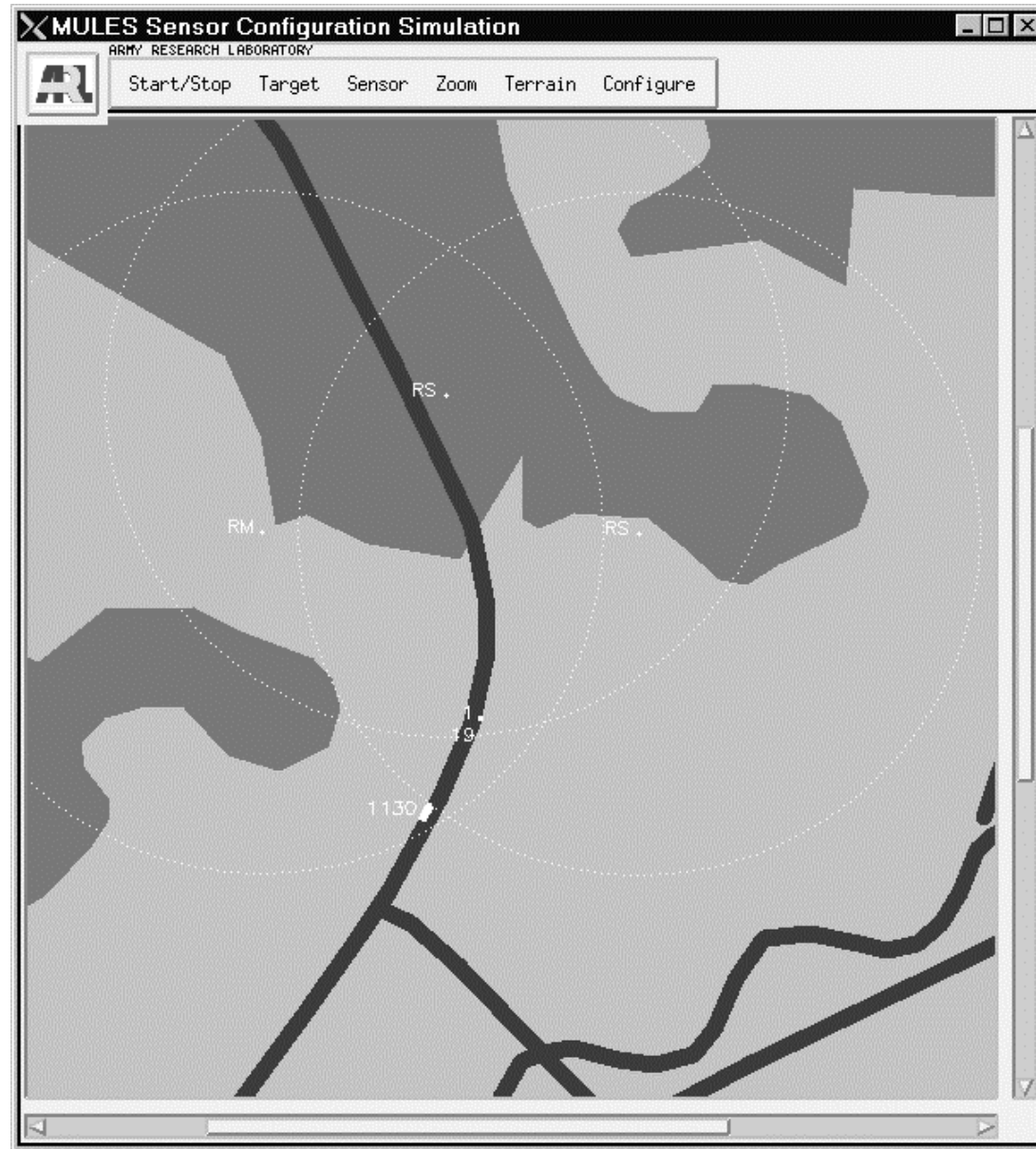


# Fusion of Detects of High Resolution Sensors



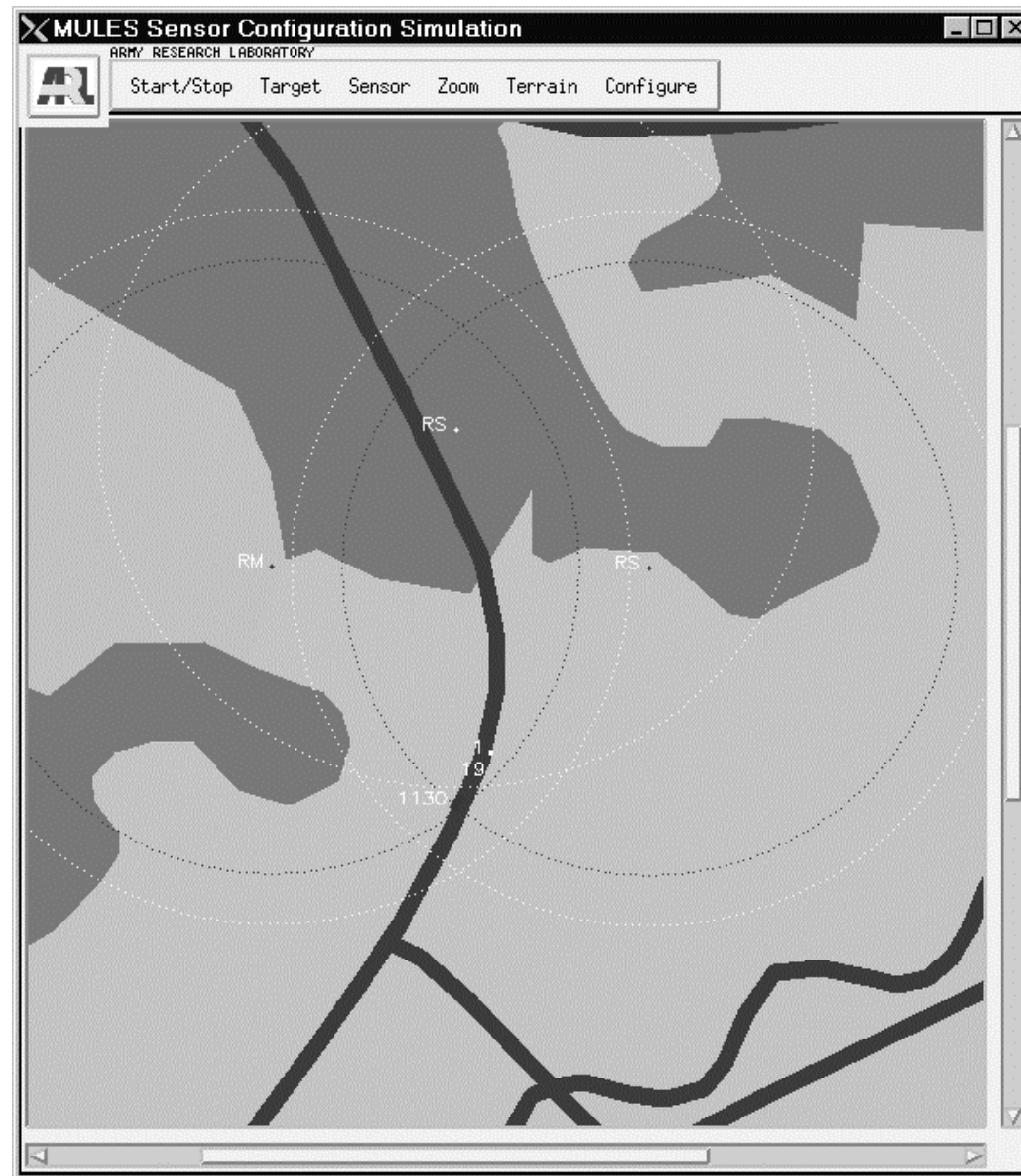


# Estimator of Target Position for Sensors with High Resolution Gates





# Estimator of Target Position for Sensors with Low Resolution Gates



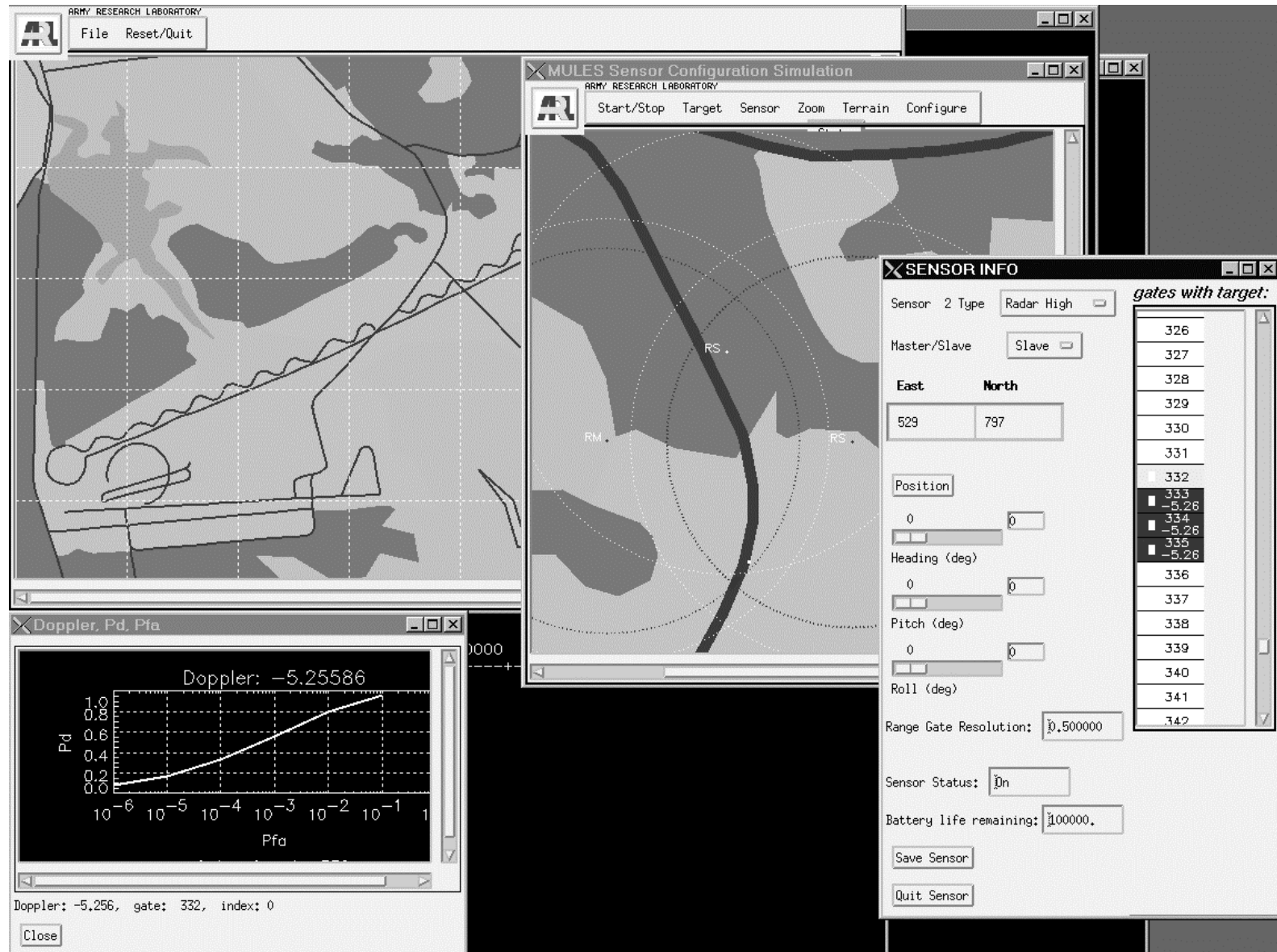


# How is Simulation Used to Evaluate Performance?

- Perturb Sensor Model
  - Trial Various Levels of Sophistication
- Vary Deployment: On-road versus Random
- Evolve Cueing Strategies
  - Who Turns Who On When, and for What Reason
- Ascertain Overall System Performance
  - Potentially in a Monte-Carlo Fashion

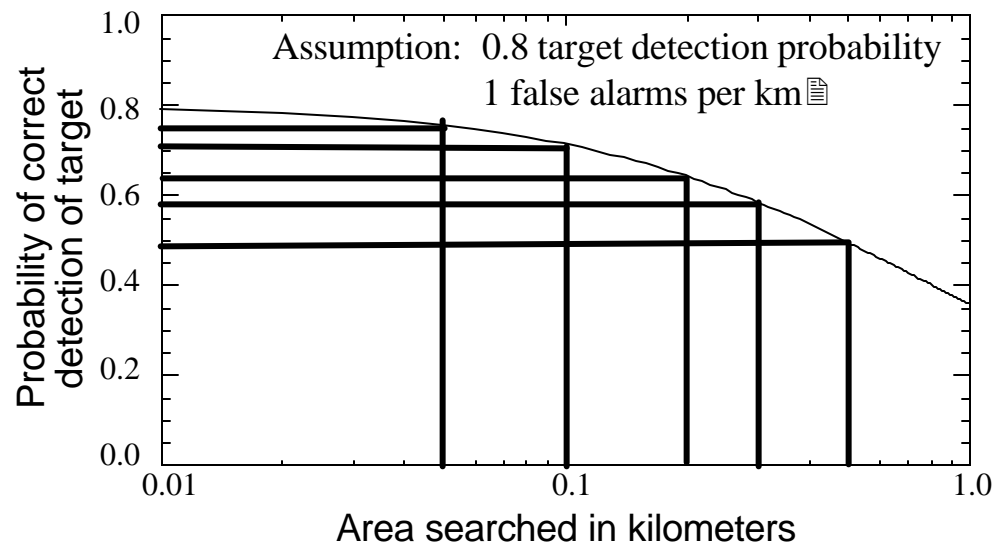
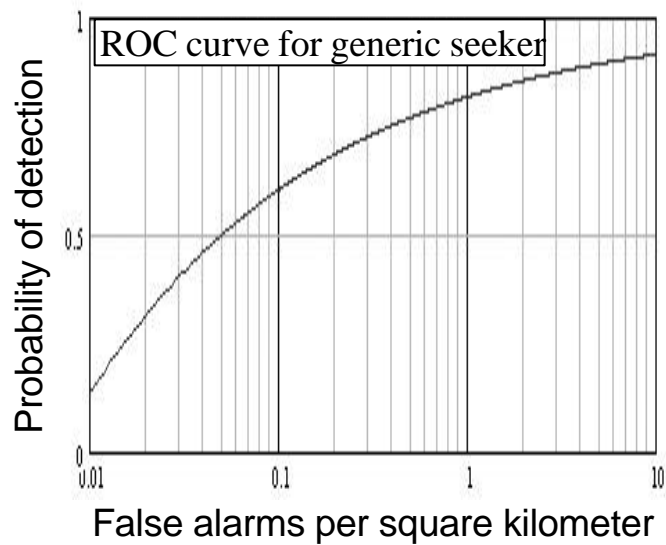
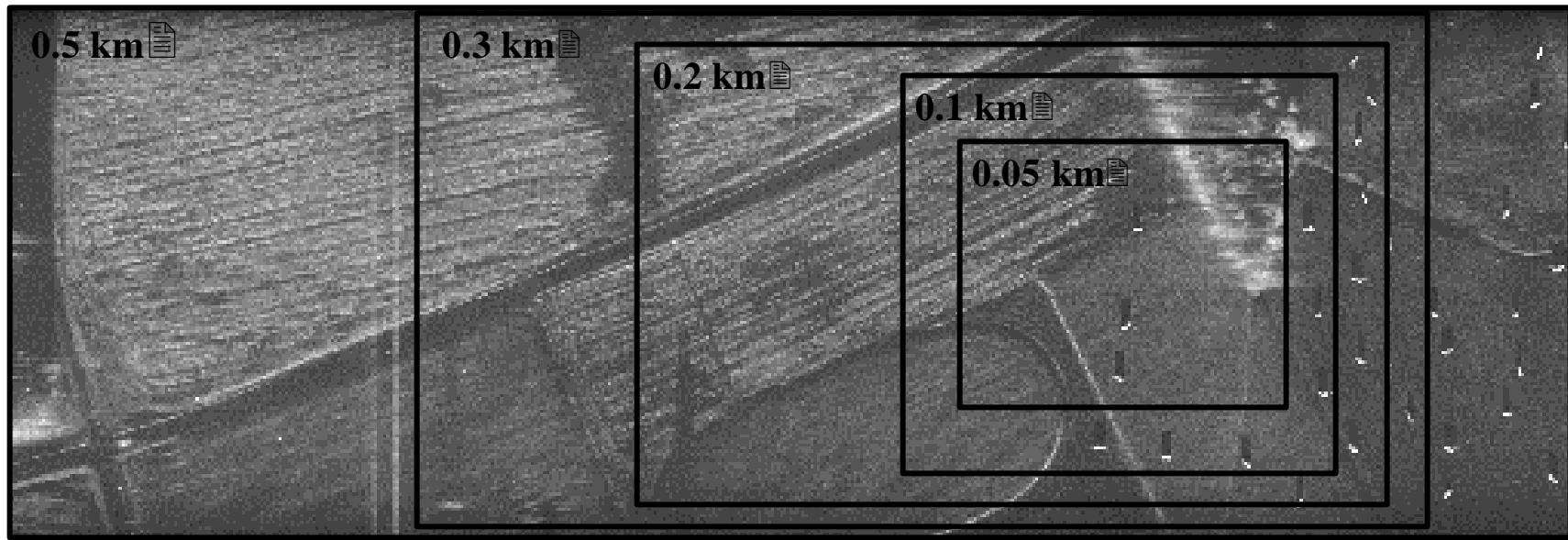


# Analysis of Detect





# Probability of correct detection vs. search area





## Probability of Detection vs. Probability of Engagement for a Moving Target

Search Area	Probability of Encounter*	False Alarms per Sq. Km	Effective Probability of Detect**	Cumulative Probability
100mx500m	0.22	1.0	0.75	0.16
		0.1	0.80	0.18
300mx500m	0.56	1.0	0.70	0.39
		0.1	0.79	0.44
500mx500m	0.76	1.0	0.60	0.46
		0.1	0.77	0.58

**\* Probability of Encounter<sup>1</sup> for a 300 m/sec flight from 8 km**  
**\*\* Probability of Detection for one target = 0.8**

<sup>1</sup> Patterson, Carolyn; *Target Location Error for the Tank Extended Range Munition*, ARL-TR-1433, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD, September 1997.

***The greatest improvement in performance can be realized by increasing Probability of Encounter through continuous re-targeting of the munition***



## Summary

- ARL effort on MRAA ATD is concentrated on determining the timeliness and quality of targeting data
  - Initially focusing on networked micro-sensors (with an RF member)
  - In future, will examine re-targeting and providing real time updates to seeker head
- Program is designed to provide multiple layers of insight
  - At the highest level, pd and location accuracy, for instance
  - At the network level, virtual experimentation of cueing and fusion strategies
  - At the sensor level, the military effectiveness of adding performance versus cost
- By establishing additional battlespace awareness (through virtual experimentation), new sensor technologies and architectures can be better assessed